FINAL TECHINICAL REPORT – USGS COOPERATIVE AGREEMENT FOR SEISMIC NETWORK OPERATIONS

Cooperative Agreement No:	USGS07HQAG0020	Project Start Date:	February 1, 2007
Network Name:	Anza Broadband and Strong Motion Seismic Network		
Project Start Date:	February 1, 2007 – January 31, 2010		
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Project Web Site:	http://eqinfo.ucsd.edu/		

Anza Network Summary:

The Anza Broadband and Strong Ground Motion Seismic Network (http://eqinfo.ucsc.edu) has been in operation for the last 27 years. It enhances the broadband coverage provided by the Southern California Seismic Network (SCSN) in southernmost California. ANZA stations are designed to operate in remote areas without any supporting infrastructure such as AC power, telephone or computer communications. Each station can operate using solar power and dedicated spread spectrum radio links for communications between the station and the IGPP. Synergy of the ANZA network with the Southern California Seismic Network (SCSN/ANSS) has been ongoing for over a decade. The ANZA Seismic Network uses broadband and strong motion sensors with 24-bit dataloggers combined with real-time telemetry to monitor local and regional seismicity in southernmost California (Figure 1).

The goal of the Anza Seismic Network is to provide on-scale digital recording of high-resolution three-component seismic data for earthquakes occurring in southern California, provide real-time data to the California Integrated Seismic Network (CISN), other regional networks, and the Advanced National Seismic System (ANSS), as well as to provide near real-time information and monitoring to the greater San Diego community. Twelve high dynamic range broadband and strong motion sensors adjacent to the San Jacinto Fault zone contribute data for earthquake source studies to the National Earthquake Reduction Program (NEHRP) and continue the monitoring of the seismic activity of the San Jacinto fault initiated 28 years ago.

Changes Implemented in this Reporting Period

During the present 3-year cooperative agreement the Anza seismic network has transitioned from producing the Anza Seismic Bulletin, which was recognized as the authoritative bulletin for events occurred along the Anza gap region along the San Jacinto fault, to being a contributing network to the SCSN/ANSS. The seismic bulletin produced since mid 2008 is generated from automatic picks, whereas earlier all events were reviewed by a seismic analyst. At present this contract agreement covers operations and routine maintenance of the network.

Map of Seismic Stations:

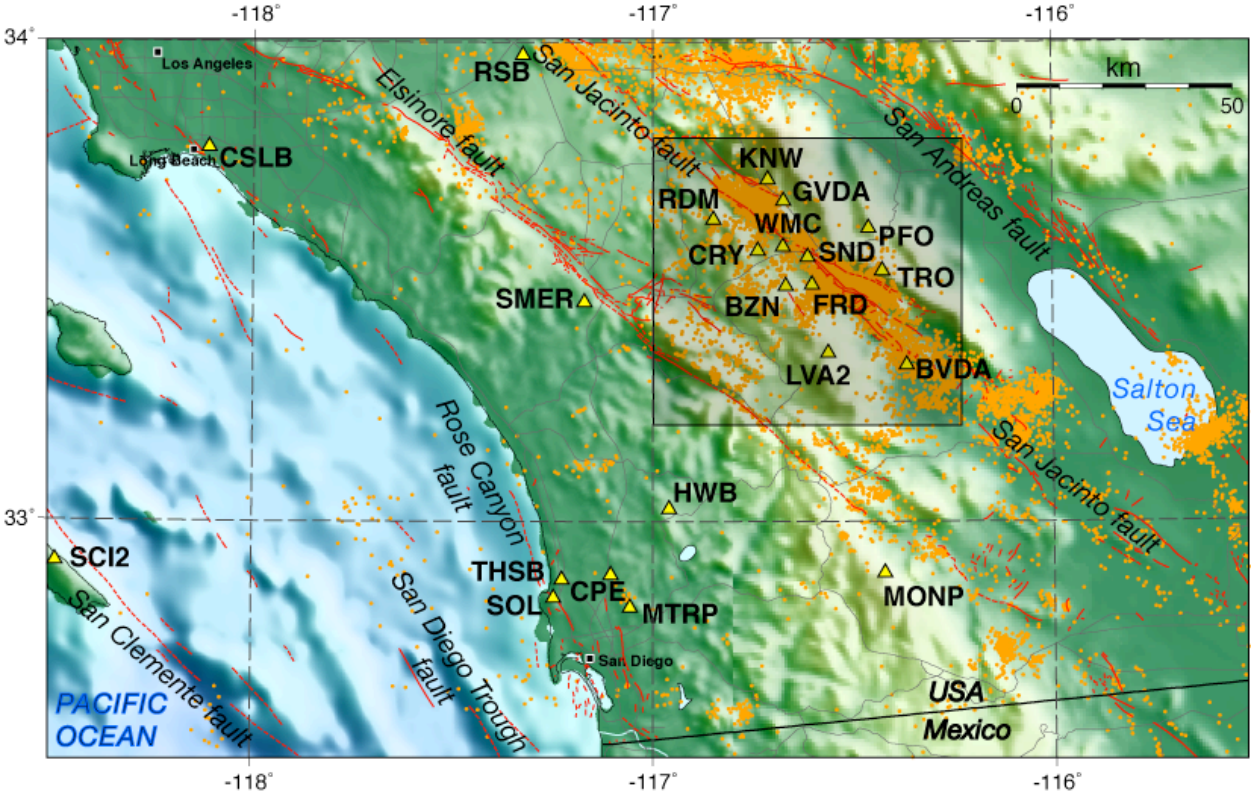

Figure 1. Map of seismicity and ANZA stations

Figure 1 shows the location of the ANZA network stations nearest to the San Jacinto fault inside the shaded area. To provide better coverage in the metropolitan San Diego area, we operate four stations in San Diego including one on Mt. Soledad (SOL) in La Jolla as well as CPE, HWB, MTRP in the urban and suburban parts of San Diego. These stations provide extended broadband and strong motion coverage to San Diego County complementing the nearest SCSN stations. The northernmost stations in this map, RSB, is operated by the SCSN.

The ANZA network stations link is http://eqinfo.ucsd.edu/deployments/anza/index.php

Data Management Practices

The Anza network complies with ANSS data management performance standards and timeliness as we transmit almost 100% of the data in quasi-real time to both the SCSN data center in Pasadena, CA as well to the IRIS Data Management System in Seattle, WA.

The ANZA network contributed 3 stations to the NSF EarthScope USArray Transportable Array (TA) footprint and had the highest data return of any of the contributing networks and higher than the TA itself.

Continuity of Operations and Response Planning

During the last 3 years an additional back-up power generator was installed at Toro Peak, as part of improvements to HPWREN (High Performance Wireless Research and Education Network) communication system. This has resulted in improved data availability for ANZA stations and has made the communication link more robust between the field stations and IGPP/UCSD.

Progress on Metadata Development

An up-to-date dataless SEED volume with the metadata for the ANZA network is available at the IRIS DMS. The link is: http://www.iris.washington.edu/dms/mda.htm

Table 1. Summary Statistics for Regional/Urban Seismic Network (as of 3

Total no. of stations operated and/or recorded	**19**
Total no. of channels recorded	**322**
No. of short-period (SP) stations	**1**
No. of short-period (SP) stations with metadata	**1**
No. of broadband (BB) stations	**19**
No. of broadband (BB) stations with metadata	**19**
No. of strong-motion (SM) stations	**8**
No. of strong-motion (SM) stations with metadata	**8**
No. of stations maintained & operated by network	**19**
-same, with full metadata	**19**
No. of stations maintained & operated as part of ANSS	**19**
-same, with full metadata	**19**
Total data volume archived (mbytes/day)	**1.1 GBytes/day**

Earthquake Data and Information Products

Network Products		
Does the network provide the following?	**Yes/No**	**Comments/Explanation**
Primary EQ Parameters		
Picks	***Yes***	***Automatic picks***
Hypocenters	***Yes***	***Automatic locations***
Magnitudes (& Amplitudes)	***Yes***	***Automatic magnitudes***
Focal mechanisms	***No***	
Moment Tensor(s)	***No***	
Other EQ Parameters/Products		
ShakeMap	***No***	
Finite Fault	***No***	
Supplemental Information		
Felt Reports	***No***	
Event Summary	***No***	
Tectonic Summary	***No***	
Collated Maps	***No***	
Refined Hypocenters (e.g. double-difference)	***No***	
Web Content		
Recent EQ Maps	***Yes***	***From automatic locations***
Station Helicorder	***No***	
Station noise PDFs	***Yes***	***Calculated at the IRIS DMC***
Station Performance Metrics	***Yes***	***Data availability DMC determined***
Network Description	***Yes***	
Station List	***Yes***	
Station Metadata	***Yes***	
Email Notification Services	***No***	
Contact Info	***Yes***	

Network Products		
Does the network provide the following?	**Yes/No**	**Comments/Explanation**
Region-specific FAQs	***Yes***	
Region-specific EQ info	***Yes***	
Waveforms		
Triggered	***No***	
Continuous	***Yes***	***3_comp: 100 sps, 40 sps and 1 sps***
Processed	***No***	
Summary Products		
Catalogs	***No***	***Anza is a Tier II network that contributes data to SCSN in real time***
Metadata		
Instrument Response	***Yes***	***Complete dataless for the network is available at the DMC***
Site Info (e.g. surface geology, Vs30)	***No***	

Descriptions:

Tectonic Summary: Text and/or figures describing the tectonic setting of the event and related activity

Event Summary: Text and/or figures (press releases, collated media/disaster agencies info) that describes the earthquake and its effects

Collated Maps: Any map or set of maps that illustrates the event properties, tectonics, hazards, etc

Processed Waveforms: Specialized processing that is required by some portion of the community, e.g. processed strong motion records for the engineering community

Catalogs: Lists of parameters that describe an earthquake(s) or information used to describe an earthquake (e.q., picks, locations, amps,..)

Region-specific earthquake information: Description (text and/or maps) of historical earthquakes, faults/geology, etc.

Tectonic Summary:

The southern California region has generated nearly 50 magnitude 6 or greater earthquakes since 1850 (Ellsworth, 1990). Sixty percent of these moderate to large earthquakes are associated with the San Andreas and San Jacinto fault systems and their continuations into Baja California. It is interesting to note that only seven of these events have significant surface rupture. These events include the 1857 Fort Tejon (Mw = 7.8) along the Cholame and Mojave segments of the San Andreas, the 1940 (Mw = 6.9) and 1979 (Mw = 6.4) on the Imperial Fault, the 1968 (Mw = 6.5) Borrego Mountain and 1987 (Mw = 6.5) Superstition Hills located on the southern San Jacinto fault, and the 1952 (Mw = 7.5) Kern County, the 1992 (Mw = 7.4) Landers, and the 1999 Hector Mine (Mw = 7.1) which are not directly associated with the San Andreas-San Jacinto fault system. These historical surface ruptures are shown in Figure 2 which also highlights the two major sections without significant surface offsets: the San Bernardino and Coachella Valley segments of the San Andreas fault and the San Bernardino, San Jacinto Valley, Anza, and the Coyote Creek segments of the San Jacinto fault.

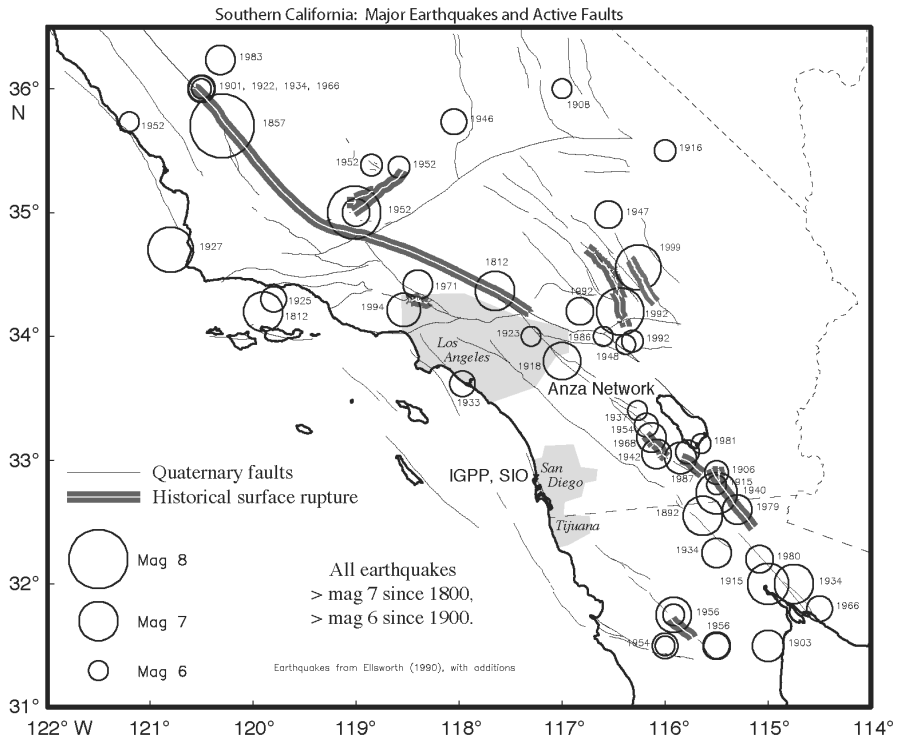

Figure 2. Major historical earthquakes in southern California. Epicenters are shown in circles and grey thick lines show surface rupture.

The San Jacinto fault zone is one of the most active strike-slip faults in southern California. The long-term slip rate is 1 cm/year, determined from 29 kilometers offset of geologic formations across the fault in the last 3 million years (Sharp, 1967). Recent measurements of offset sediments in the Anza Valley yield a similar slip rate (Rockwell, et al. 1990). The Anza segment of the San Jacinto fault zone has been identified by Thatcher et al. (1975) as a seismic slip gap for a $6 \leq M \leq 7$ earthquake. The study of Sanders and Kanamori (1984) revealed a 15 km element of the estimated seismic gap that has been virtually aseismic in modern times. Klinger and Rockwell (1989) trenched the San Jacinto Fault at Hog

Lake located in the center of the Anza seismic gap and found evidence for surface rupture from three events since 1210. Additional evidence suggests that these events occurred about 1210, 1530 and 1750.

In 1988, the Working Group on California Earthquake Probabilities (USGS Open File Report 88-398) defined the Anza segment to be the 50 km section between the southern end of the inferred 1899 M=6.4 (Abe, 1988), 1918 M=6.8 (Ellsworth, 1990) rupture just north of Anza and the north end of the 1968 Borrego Mountain M=6.8 surface rupture. They used a slip rate of 11 mm/yr, a recurrence interval of 142 years, and assumed the previous event in this segment was 1892. Based on this information a probability of 0.3 was assigned for a magnitude seven (M=7) earthquake in the Anza area in the next 30 years.

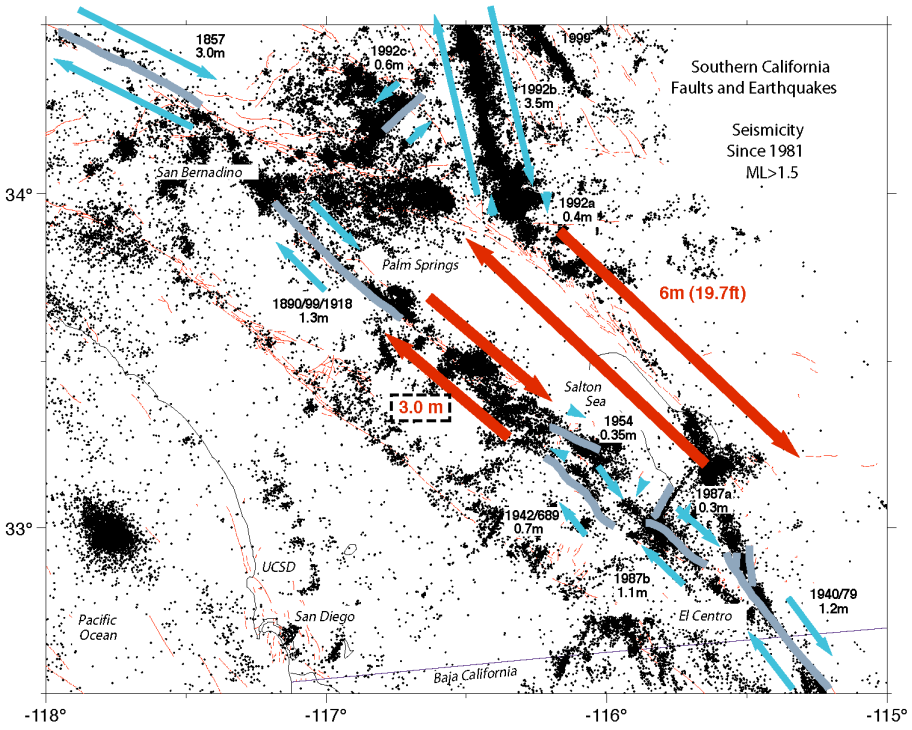

Figure 3. Seismicity in the southern California region since 1981 with Ml > 1.5. Major earthquakes with observed or inferred offsets are shown with blue arrows. The red arrows designate the two major slip deficits in southern California, 3 meters for the Anza gap on the San Jacinto fault and 6 meters for the Coachella segment of the San Andreas s fault. Earthquakes of magnitudes 7+ and 8+ respectively are required to eliminate these slip deficits.

The Southern California Earthquake Center presented its Phase II report that reassesses the results of the 1988 report. Using the results of Klinger and Rockwell (1989) and Rockwell et al. (1990), the Anza segment of the San Jacinto fault zone is considered by the Working Group on California Earthquake Probabilities (1995) to be the entire 90 km long Clark fault with an average repeat time for a magnitude 7.0 to 7.5 to be 250 (+321, -145) years. Because the dimension of the segment increased, the characteristic slip is now 3.0 m (Figure 3).

The most significant recent information to be developed for the seismic potential of the Anza segment is the 1750 date for the last major earthquake. Using the 142-year recurrence interval of the 1988 report a magnitude 7.0 earthquake is now 100 years overdue. If one prefers the Phase II report, then the characteristic earthquake can be a magnitude 7.5 with the peak in the conditional probability distribution in the year 2000. In either scenario, the characteristic earthquake can generate significant damage in the major population areas of San Diego (90 km distant), the San Bernardino Valley (60 km), and the Los Angeles basin (90-150 km) (Figure 3). In similar situations, significant damage was caused in San Francisco at 120 km distance by the magnitude 6.9 1989 Loma Prieta and in various parts of the Los Angeles basin by the magnitude 6.7 1994 Northridge earthquake over 100 km from the source.

Regional Activity recorded from 2007/02/01 to 2010/02/01

During this three-year contract period the Anza network located 13,500 events, including regional and teleseismic events. The mayority, 11,673 events were located within parallels 30° N to 36 ° N and western meridians 114 ° and 119° as shown in Figure 4. The Anza network recorded 40 events larger than Ml 3.9 in this same period and region.

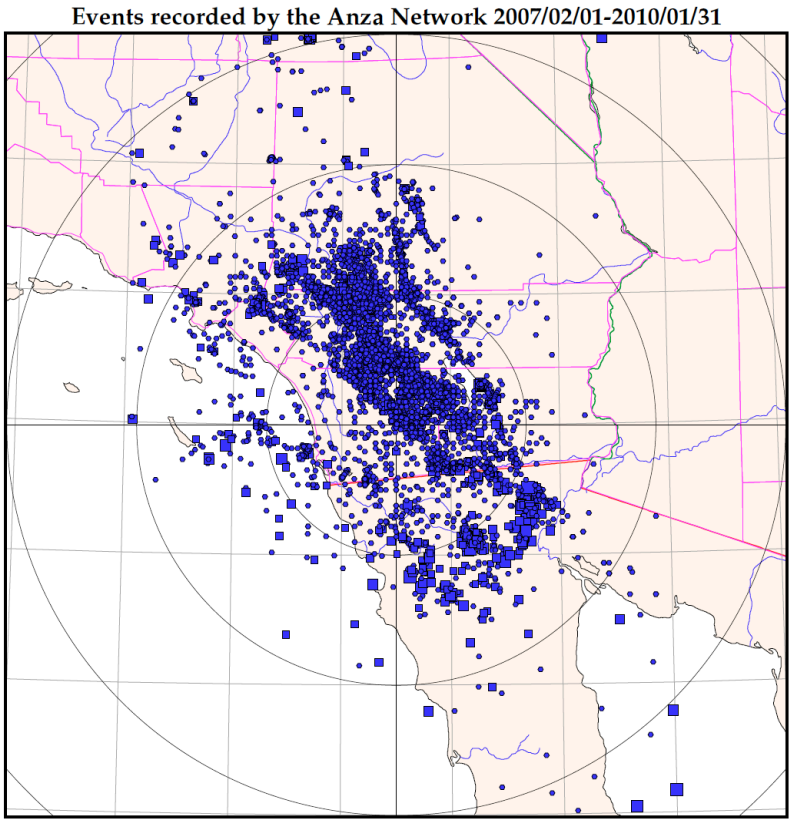

Figure 4. Seismicity located by the Anza Seismic Network, centered at 33° N and 116.5° W. The circles shown are at 1° distance intervals.

The magnitude (Ml) distribution for these 11,673 events is shown in Figure 5.

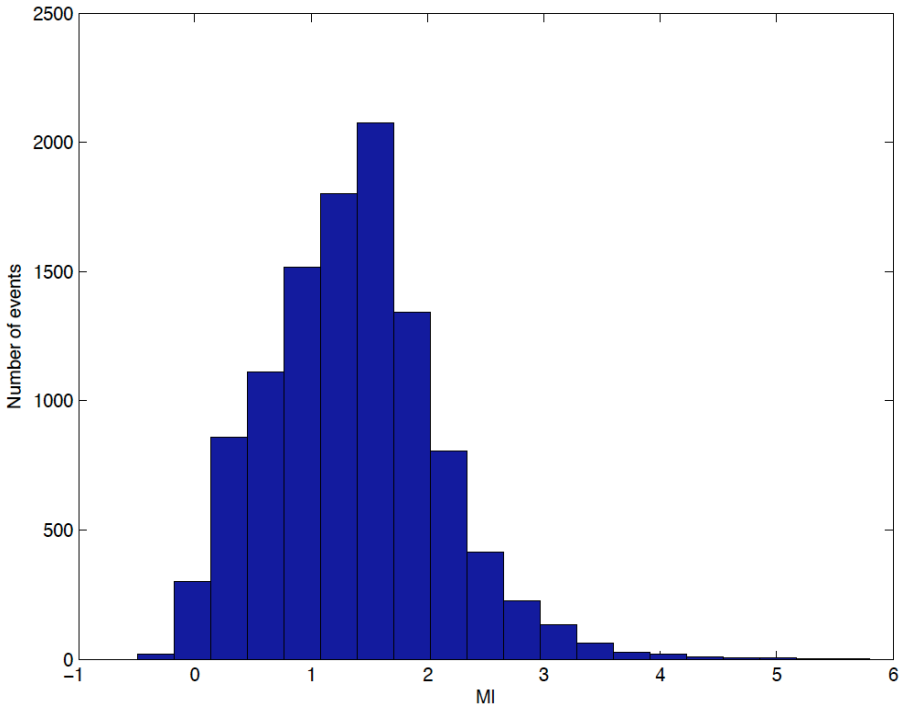

Figure 5. Histogram showing the magnitude distribution of regional events recorded by the Anza network seismic stations from February 1, 2007 to January 31, 2010.

We produce special event pages for teleseismic events with M >6.9, as well as any regional event with M > 3.9 or any local felt earthquake (http://eqinfo.ucsd.edu/special_events/) for which a location map is shown as well as recorded waveforms.

The largest regional event recorded by the Anza network during the contract period was a M=6.9 occurred on Augst 3, 2009 in the Gulf of California,. Seismic activity south of the border during 2009 was abundant, with a swarm occurring near Mexicali, BCN, Mexico in October 2009, the link for these special events is: http://eqinfo.ucsd.edu/special_events/2008/mexicali_swarm/